Published in final edited form as:

J Am Coll Surg. 2016 July ; 223(1): 142–151. doi:10.1016/j.jamcollsurg.2016.04.042.

Vulnerable Hospitals and Cancer Surgery Readmissions: Insights into the Unintended Consequences of the Patient Protection and Affordable Care Act

Young Hong, MD, Chaoyi Zheng, MS, Elizabeth Hechenbleikner, MD, Lynt B Johnson, MD, FACS, Nawar Shara, PhD, and Waddah B Al-Refaie, MD, FACS

Department of Surgery, MedStar Georgetown University Hospital (Hong, Zheng, Hechenbleikner, Johnson, Al-Refaie), MedStar Health Research Institute (Shara, Al-Refaie), MedStar-Georgetown Surgical Outcomes Research Center (Al-Refaie), and Georgetown Lombardi Comprehensive Cancer Center (Al-Refaie), Washington, DC.

Abstract

BACKGROUND—Penalties from the Hospital Readmission Reduction Program can push financially strained, vulnerable patient-serving hospitals into additional hardship. In this study, we quantified the association between vulnerable hospitals and readmissions and examined the respective contributions of patient- and hospital-related factors.

METHODS—A total of 110,857 patients who underwent major cancer operations were identified from the 2004–2011 State Inpatient Database of California. Vulnerable hospitals were defined as either self-identified safety net hospitals (SNHs) or hospitals with a high percentage of Medicaid patients (high Medicaid hospitals [HMHs]). We used multivariable logistic regression to determine the association between vulnerable hospitals and readmission. Patient and hospital contributions to the elevation in odds of readmission were assessed by comparing estimates from models with different subsets of predictors.

RESULTS—Of the 355 hospitals, 13 were SNHs and 31 were HMHs. After adjusting for Hospital Readmission Reduction Program variables, SNHs had higher 30-day (odds ratio [OR] = 1.32; 95% CI, 1.18–1.47), 90-day (OR = 1.28; 95% CI, 1.18–1.38), and repeated readmissions (OR = 1.33; 95% CI, 1.18–1.49); HMHs also had higher 30-day (OR = 1.18; 95% CI, 1.05–1.32), 90-day (OR = 1.28; 95% CI, 1.16–1.42), and repeated readmissions (OR = 1.24; 95% CI, 1.01–1.54). Compared with patient characteristics, hospital factors accounted for a larger proportion of

Correspondence address: Waddah B Al-Refaie, MD, FACS, Department of Surgery, MedStar Georgetown University Hospital, Georgetown Lombardi Comprehensive Cancer Center, 3800 Reservoir Rd NW, 4PHC, Washington, DC 20007. wba6@georgetown.edu.

Disclosure Information: Nothing to disclose.

Presented at the Western Surgical Association 123rd Scientific Session, Napa Valley, CA, November 2015.

Author Contributions

Study conception and design: Hong, Zheng, Hechenbleikner, Johnson, Shara, Al-Refaie

Acquisition of data: Hong, Zheng, Hechenbleikner, Johnson, Shara, Al-Refaie

Analysis and interpretation of data: Hong, Zheng, Hechenbleikner, Johnson, Shara, Al-Refaie

Drafting of manuscript: Hong, Zheng, Hechenbleikner, Johnson, Shara, Al-Refaie

Critical revision: Hong, Zheng, Hechenbleikner, Johnson, Shara, Al-Refaie

the increase in odds of readmission among SNHs (60% to 93% vs 24% to 39%), but a smaller proportion among HMHs (9% to 15% vs 60% to 115%).

CONCLUSIONS—Vulnerable status of hospitals is associated with higher readmission rates after major cancer surgery. These findings reinforce the call to account for socioeconomic variables in risk adjustments for hospitals who serve a disproportionate share of disadvantaged patients.

Readmission reduction was a key provision of the Patient Protection and Affordable Care Act of 2010. In an effort to improve quality and control costs, the Center for Medicare and Medicaid Services formed the Hospital Readmission Reduction Program (HRRP), which financially penalizes hospitals with higher than benchmark 30-day readmission rates from the time of discharge for chronic medical conditions (eg acute MI, heart failure, and pneumonia). These penalties are gradually growing to include surgical procedures such as, for now, orthopaedics and vascular surgery.¹

However, concerns about unintended consequences of the HRRP penalties are gaining some momentum.^{1,2} In particular, vulnerable hospitals are typically under-resourced, highly used, and serve large proportions of minority, multi-morbid, Medicaid beneficiary, and uninsured patients.³ These hospitals often operate within narrow financial margins, with considerable dependence on disproportionate-share hospital funding.⁴ With the 2010 Patient Protection and Affordable Care Act reducing disproportionate-share hospital reimbursements as the coverage expansion rolls out, it is speculated that the HRRP penalties, if assessed, will push vulnerable hospitals into additional financial hardship. To date, little is known about the effect of vulnerable status of the operating hospital on readmissions after cancer surgery. Such knowledge is of broad interest, especially when hospitals and health care systems are incentivized to join accountable care organizations.

To fill this important gap, our study sought to evaluate cancer surgery readmission rates at vulnerable hospitals. We aimed to quantify the impact of receiving major cancer surgery at vulnerable hospitals (high Medicaid hospitals [HMHs] or safety net hospitals [SNHs]) on 30-day, 90-day, and repeated readmissions. Additionally, given that characteristics of vulnerable hospitals can contribute to worse operative outcomes,^{5,6} the degree to which hospital and patient factors contributed to these higher readmission rates was examined.

METHODS

Data source

California is the largest state by population (12% of the entire US population)⁷ and one of the most racially diverse states⁸ in the United States. The State Inpatient Database of California contains discharge records from all non-federal hospitals in California⁹ and provides deidentified patient identification to enable linking multiple episodes of hospitalizations of the same individual.¹⁰ This database was linked to the Annual Survey Database of the American Hospital Association, which provides detailed information on structural characteristics of hospitals.

Patient selection

Discharge data for 110,857 adult patients who underwent major cancer surgery between January 1, 2004 and September 30, 2011 were abstracted. In accordance with previous studies,^{11,12} 7 major or complex cancer procedures were included in the analyses: esophagectomy, total and distal gastrectomy, pancreatectomy, hepatectomy, proctectomy, lung resections, and partial and total nephrectomy.

Vulnerable hospitals

The predictor of primary interest in our study was the vulnerable status of a hospital. In this study, we define vulnerable hospitals as having a high proportion of Medicaid patients (HMHs), or being an SNH, or both (high Medicaid safety net hospitals [HMSNH]). Specifically, we define HMHs as those that rank in the top decile among all California hospitals in terms of percentage of inpatient discharges with Medicaid as the primary source of payment; an SNH was identified as being a member of the California Association of Public Hospitals and Health Systems.¹³ Among the 355 hospitals that performed major cancer surgery, there were 31 HMHs (n = 2,106 patients), 13 SNHs (n = 8,267 patients), and 5 HMSNHs (n = 521 patients); the remaining 306 hospitals were considered nonvulnerable hospitals (n = 99,963 patients).

Dependent variables

Readmissions within 30 days of discharge from the index admission were the key measure used in HRRP evaluation¹⁴ and were therefore the natural subject for this study. We also examined 90-day and repeated readmissions because they bear clinical relevance to both patients and providers, capturing delayed effects of the indexed admission. Readmissions to all non-federal California hospitals were counted in this study.

Covariates

Three sets of covariates were used in this study. The first set comprised patient's age, sex, level of comorbidity measured by the Charlson Index, and type and year of procedure. These covariates were used to simulate the risk-adjustment scheme in HRRP, which uses single-year and single-procedure models that adjust for age, sex, and comorbidity. The second set included other important patient characteristics, such as race and ethnicity, ZIP code-level median income, primary insurance, and emergency status of the index operation. The last set was hospital structure characteristics, including number of hospital beds, residency training program, Commission on Cancer-approved cancer program, and the procedure volume of hospital. Procedure volume was evaluated each year for each procedure and categorized into low, medium, and high, where each category performed one third of all procedures of that type and in that year.

Statistical methods

Distributions of patient demographic and clinical features and hospital characteristics were compared between vulnerable and nonvulnerable hospitals, as well as among the 3 types of vulnerable hospitals (SNH, HMH, and HMSNH) via chi-square tests. Generalized estimating equations were used for logistic models to assess the effect of hospital vulnerable

status on rates of 30-day, 90-day, and repeated readmissions and controlling for hospital-level clustering. For each outcome, an unadjusted model and a base model adjusting for the HRRP covariates were constructed first, then 2 subsequent models were constructed, adjusting for other patient factors and hospital factors, respectively. Percentage changes from the base model in odds ratio (OR) associated with vulnerable vs nonvulnerable hospitals were calculated for each of these 2 models; these percentages represented the amount of elevation in readmission risk exhibited in the base model mediated by the respective additional covariates; that is, percentage change in OR = $(OR_{\text{Model 2}} - OR_{\text{Model 3 or 4}}) / (OR_{\text{Model 2}} - 1) \times 100\%$. Finally, a full model that included all covariates was built. All analyses were performed with SAS, version 9.4 (SAS Institute). All missing values in covariates were included in the models as a new category in each covariate. All tests were 2-sided and used an α of 0.05.

RESULTS

Descriptive statistics

The 30-day readmission rates were 11.1%, 13.6%, 12.8%, and 13.9% among nonvulnerable hospitals, SNH, HMH, and HMSNH, respectively. Ninety-day readmission rates were 17.3%, 19.8%, 22.4%, and 20.7%, respectively, and the repeated readmission rates were 3.1%, 4.1%, 4.2%, and 5.2%, respectively.

Compared with patients who underwent major cancer surgery at nonvulnerable hospitals, patients at vulnerable hospitals were more likely to be younger (percentage of 18- to 49-year-olds: 27.2% vs 17.5%), have fewer comorbidities (percentage with Charlson Index of 0: 63% vs 58.4%), be Hispanic (27.2% vs 13.7%) or non-Hispanic black (8.3% vs 5.6%), live in lower-income areas (percentage living in ZIP code areas with income in the first quartile in California: 27.8% vs 16.6%), have Medicaid (26.9% vs 5.0%), and be admitted via the emergency department for their index surgery (14.6% vs 8.5%; $p < 0.001$) (Table 1).

Substantial variations also existed among different types of vulnerable hospitals. For instance, the percentage of Hispanic patients among all patients of major cancer operations was much higher at HMHs than at SNHs and HMSNHs (40.8% vs 23.9% and 25.1%, respectively). Meanwhile, HMSNHs saw the highest percentage of major cancer surgery patients with Medicaid (40.7% vs 26.9% in SNHs and 23.5% in HMHs). Compared with SNHs, HMHs and HMSNHs also had much lower procedure volumes (percentages of patients who underwent surgery in hospitals with low procedure volume for the specific procedure were 80.3% and 97.3% vs 24.5%, respectively).

Other hospital structural characteristics were summarized by type of hospital in Table 2. Safety net hospitals and HMSNHs were more likely to have Commission on Cancer-approved cancer programs and much more likely to be teaching hospitals than nonvulnerable hospitals and HMHs. Many of the HMHs were private for-profit hospitals ($n = 15$ of 31), only 17.3% of nonvulnerable hospitals ($n = 53$ of 306) were for profit, and all SNHs and HMSNHs were public hospitals.

Multivariate regression analysis of vulnerable hospitals and readmission rates

Table 3 summarizes the ORs associated with different types of vulnerable hospitals vs nonvulnerable hospitals in the 5 models. The relative change in OR was calculated for model 3 (HRRP + patient factors) and model 4 (HRRP + hospital factors), respectively. Among patients at SNHs, the additional non-HRRP patient factors explained more change in the ORs associated with SNHs vs nonvulnerable hospitals than the hospital factors: 24% vs 60% for 30-day readmissions, 39% vs 66% for 60-day readmissions, and 39% vs 93% for repeated readmissions. However, the relative explanatory power between patient and hospital factors was reversed for patients at HMMH: 115% vs 15% for 30-day readmissions, 60% vs 10% for 90-day readmissions, and 82% vs 9% for repeated readmissions. Among patients at HMMNH, patient and hospital factors explained a slightly smaller amount of change in the ORs: 52% vs 69% for 30-day readmissions, 71% vs 77% for 90-day readmissions, and 55% vs 63% for repeated readmissions.

After adjustment of all covariates (model 5), most elevation in risk for readmission among vulnerable hospitals was accounted for, with the exception of 90-day readmissions at HMMHs (OR = 1.11; 95% CI, 1.01–1.23). The ORs associated with each covariate are presented in Table 4. In general, the 3 measures of readmissions shared similar risk factors, including extensive and high-risk procedures, younger age, higher comorbidity, having public insurance, and being readmitted for index surgery via the emergency department. The teaching status of operative hospitals was associated with an elevated risk for readmission (30-day readmission OR = 1.15; 95% CI, 1.07–1.24; 90-day readmission OR = 1.14; 95% CI, 1.06–1.22; and repeated readmission OR = 1.23; 95% CI, 1.11–1.38). Notably, low procedure volume was associated with a slightly decreased risk for repeated readmission (OR = 0.85; 95% CI, 0.75–0.95). The emergency status of major cancer surgery (30-day readmissions OR = 1.51; 95% CI, 1.41–1.63; 90-day readmissions OR = 1.51; 95% CI, 1.41–1.62; and repeated readmissions OR = 1.79; 95% CI, 1.59–2.02) and higher Charlson Index (30-day readmissions OR = 1.87; 95% CI, 1.75–2.00; 90-day readmission OR = 1.96; 95% CI, 1.87–2.06; and repeated readmission OR = 2.32; 95% CI, 2.12–2.54) was associated with higher readmission rates, both of which have higher prevalence in HMMH than in SNH.

DISCUSSION

In this large and diverse multi-hospital appraisal, we analyzed the readmission rates after major cancer surgery performed at vulnerable hospitals, HMMHs and SNHs, compared with those performed at nonvulnerable hospitals. Our study demonstrated that HMMHs and SNHs experience higher readmission rates after major cancer surgery than nonvulnerable hospitals using the HRRP formulae. The primary contributors of higher readmission at the HMMHs were patient-related factors, and the primary drivers of higher readmission at SNH were hospital-related factors.

In agreement with our findings, previous studies have reported that SNHs were more likely to be penalized under value-based purchasing and HRRP than nonvulnerable hospitals.^{15–17} In a similar analysis by Hoehn and colleagues,¹⁸ worse surgical outcomes and increased readmissions were found at SNHs when compared with non-SNHs. The observed higher

mortality, readmission rates, and cost of care were largely attributed to hospital-related factors rather than patient-related factors.¹⁸ These findings were reinforced by a recent systematic review that found that SNHs had worse performance than non-SNHs in measures of timeliness and patient-centeredness, with less equitable surgical care.¹⁹ These investigations, together with ours, suggest that increased SNH readmission rates might be driven predominantly by hospitals rather than patient factors.

Paradoxically, the current analysis suggests that higher readmission rates at SNHs might be driven largely by hospital factors.^{18,19} Similar to a systematic review by Mouch and colleagues,¹⁹ which evaluated the quality of SNHs based on hospital factors of safety, effectiveness, efficiency, timeliness, patient-centeredness, and equity, our study focused on hospital factors, such as number of beds, ownership status, teaching status, and having a Commission on Cancer-designated cancer program within the American Hospital Association database. Although different variables were analyzed for patient care outcomes at SNH, both studies revealed hospital-based infrastructures that were inferior to those of non-SNHs. Similar hospital factors of higher number of beds, teaching status, and greater institutional volume were identified as reasons for higher readmissions after sepsis.²⁰

Although it is well known that high procedural volume is often associated with lower readmission rates,²⁰ SNHs in our cohort had higher readmission patterns despite having high procedural volumes. One plausible explanation is that SNHs also performed higher volumes of complex foregut and hepatobiliary cases of pancreatic, esophageal, and liver disease than HMHs and nonvulnerable hospitals.

There were several limitations in our work. First, there were inherent variations in the use and entry of administrative data with ICD-9 coding. This inevitably led to a lack of granularity in readmission diagnoses and conditions of readmission, which might not have depicted the full picture of the readmission encounter. Second, tumor and treatment characteristics, such as stage and grade were unavailable. Given earlier evidence that Medicaid patients typically present with either an advanced stage of cancer or the need for urgent cancer surgery, it is plausible that patients with advanced-stage cancer were more likely to be readmitted than those diagnosed with earlier stages.²¹ Third, in line with other literature on SNHs, there was a lack of clear consensus on the definition of an SNH, where alternative definitions have been used (eg the highest proportion of disproportionate-share hospitals received).⁴ It is possible that our list of SNHs might have differed from SNHs identified by other criteria. Last but not least, the changes in OR were calculated based on point estimates and no statistical procedures were applied to test their significance.

However, despite some of the limitations mentioned so far, the current study has several positive attributes. Our findings stemmed from the large, racially diverse population of California and the database was linked to the American Hospital Association. Together, these linked data provided a deeper understanding of the drivers of readmissions after cancer surgery within a wide spectrum of vulnerable hospitals. The study identified several types of vulnerable hospital categorizations (HMH, SNH, or both) that are susceptible under the HRRP penalty system, and it uncovered potential primary contributors of higher readmissions rates for future quality-improvement and policy initiatives.

The current study has several implications. First, our study contributes to the growing body of literature that explores the unintended consequences of the HRRP penalty system on vulnerable hospitals.¹⁵ Implications of identifying patient factors as a primary driver of readmission in HMH (as vulnerable hospitals) highlight the need to account for social determinants in future amendments of the HRRP penalty formulae. The possible implications of not risk-adjusting patient socioeconomic factors can drive the crowding-out effect of hospitals having risk aversion to higher readmission penalties. Our observations of the contribution of hospital factors to the higher readmission rates at SNHs serve as a platform for future quality-improvement initiatives, including perioperative care coordination of surgical patients to close the gaps in transition of care to an outpatient setting after their complex procedures in attempts to lower these readmissions.²²

CONCLUSIONS

Our study demonstrated higher 30-day, 90-day, and repeated readmissions after major cancer operations performed at vulnerable hospitals, such as HMHs and SNHs, compared with nonvulnerable hospitals. Higher readmissions place these vulnerable hospitals at risk for additional financial penalties under the current HRRP penalty system, in addition to their narrow financial profit margin. Our study provides additional insights into different drivers of increased readmissions that are dependent on the vulnerability of the indexed hospital. These findings have policy implications to amend the current HRRP penalty system to account for socioeconomic variables to provide risk adjustments for hospitals who already serve a disproportionate number of disadvantaged patients.

Abbreviations and Acronyms

HMH	high Medicaid hospital
HMSNH	high Medicaid safety net hospital
HRRP	Hospital Readmission Reduction Program
SNH	safety net hospital

REFERENCES

1. Tsai TC, Jha AK. Surgical-readmission rates and quality of care. *N Engl J Med*. 2013; 369:2460–2461.
2. Hawn MT. Unintended consequences of the hospital readmission reduction program. *Ann Surg*. 2015; 261:1032–1033. [PubMed: 25647062]
3. Tsai TC, Orav EJ, Joynt KE. Disparities in surgical 30-day readmission rates for Medicare beneficiaries by race and site of care. *Ann Surg*. 2014; 259:1086–1090. [PubMed: 24441810]
4. Gilman M, Hockenberry JM, Wilson IB, et al. California safety-net hospitals likely to be penalized by ACA value, readmission, and meaningful-use programs. *Health Aff (Millwood)*. 2014; 33:1314–1322. [PubMed: 25092831]
5. Birkmeyer JD, Dimick JB, Birkmeyer NJ. Measuring the quality of surgical care: structure, process, or outcomes? *J Am Coll Surg*. 2004; 198:626–632. [PubMed: 15051016]
6. Rhoads KF, Ackerson AK, Jha AK, et al. Quality of colon cancer outcomes in hospitals with a high percentage of Medicaid patients. *J Am Coll Surg*. 2008; 207:197–204. [PubMed: 18656047]

7. US Census Bureau. [Accessed December 3, 2015] Florida passes New York to become nation's third most populous state. Available at: <http://www.census.gov/newsroom/press-releases/2014/cb14-232.html>
8. Population distribution by race/ethnicity. [Accessed December 3, 2015] Available at: <http://kff.org/other/state-indicator/distribution-by-raceethnicity/>.
9. [Accessed December 3, 2015] About the SID. Available at: <https://www.hcup-us.ahrq.gov/sidoverview.jsp#about>
10. [Accessed April 15, 2015] HCUP supplemental variables for revisit analyses. Available at: <https://www.hcup-us.ahrq.gov/toolssoftware/revisit/revisit.jsp>
11. Langan RC, Huang CC, Colton S, et al. Readmissions after major cancer surgery among older adults. *Surgery*. 2015; 158:428–437. [PubMed: 26003911]
12. Zheng C, Habermann EB, Shara NM, et al. Fragmentation of care after surgical discharge: non-index readmission after major cancer surgery. *J Am Coll Surg*. 2016; 222:780–789.e2. [PubMed: 27016905]
13. California Association of Public Hospitals and Health Systems. About CAPH. [Accessed December 3, 2015] Available at: <http://caph.org/aboutcaph/>.
14. The Patient Protection and Affordable Care Act, HR 3590, 111th Congress Sess (209–2010).
15. Joynt KE, Jha AK. Characteristics of hospitals receiving penalties under the Hospital Readmissions Reduction Program. *JAMA*. 2013; 309:342–343. [PubMed: 23340629]
16. Rajaram R, Chung JW, Kinnier CV, et al. Hospital characteristics associated with penalties in the Centers for Medicare & Medicaid Services Hospital-Acquired Condition Reduction Program. *JAMA*. 2015; 314:375–383. [PubMed: 26219055]
17. Gilman M, Adams EK, Hockenberry JM, et al. Safety-net hospitals more likely than other hospitals to fare poorly under Medicare's value-based purchasing. *Health Aff (Millwood)*. 2015; 34:398–405. [PubMed: 25732489]
18. Hoehn RS, Wima K, Vestal MA, et al. Effect of hospital safety-net burden on cost and outcomes after surgery. *JAMA Surg*. 2016; 151:120–128. [PubMed: 26466334]
19. Mouch CA, Regenbogen SE, Revels SL, et al. The quality of surgical care in safety net hospitals: a systematic review. *Surgery*. 2014; 155:826–838. [PubMed: 24787109]
20. Tsai TC, Joynt KE, Orav EJ, et al. Variation in surgical-readmission rates and quality of hospital care. *N Engl J Med*. 2013; 369:1134–1142. [PubMed: 24047062]
21. Rhoads KF, Ngo JV, Ma Y, et al. Do hospitals that serve a high percentage of Medicaid patients perform well on evidence-based guidelines for colon cancer care? *J Health Care Poor Underserved*. 2013; 24:1180–1193. [PubMed: 23974390]
22. Balaban RB, Galbraith AA, Burns ME, et al. A patient navigator intervention to reduce hospital readmissions among high-risk safety-net patients: a randomized controlled trial. *J Gen Intern Med*. 2015; 30:907–915. [PubMed: 25617166]

Distribution of Demographic, Clinical, and Hospital Characteristics among Patients of Major Cancer Surgery in California by Type of Hospital, State Inpatient Database of California, 2004 to 2011 (N = 110,857)

Table 1

Demographic	Vulnerable status		Type of vulnerable hospital				
	Nonvulnerable (n = 99,963)	Vulnerable hospitals (n = 10,894)	p Value	Safety net hospitals (n = 8,267)	High Medicaid hospitals (n = 2,106)	High Medicaid and safety net hospitals (n = 521)	p Value
Procedure type			<0.001				<0.001
Esophageal	2,105 (2.1)	250 (2.3)		239 (2.9)	3 (0.1)	8 (1.5)	
Gastric	10,254 (10.3)	1,390 (12.8)		763 (9.2)	538 (25.5)	89 (17.1)	
Liver	2,063 (2.1)	251 (2.3)		213 (2.6)	21 (1.0)	17 (3.3)	
Pancreatic	8,011 (8.0)	1,277 (11.7)		1,149 (13.9)	83 (3.9)	45 (8.6)	
Rectal	19,429 (19.4)	1,535 (14.1)		994 (12.0)	449 (21.3)	92 (17.7)	
Lung	23,086 (23.1)	1,709 (15.7)		1,358 (16.4)	290 (13.8)	61 (11.7)	
Kidney	35,015 (35.0)	4,482 (41.1)		3,551 (43.0)	722 (34.3)	209 (40.1)	
Age group			<0.001				<0.001
18 to 49 y	17,534 (17.5)	2,958 (27.2)		2,367 (28.6)	412 (19.6)	179 (34.4)	
50 to 64 y	31,436 (31.4)	4,345 (39.9)		3,483 (42.1)	603 (28.6)	259 (49.7)	
65 to 74 y	27,214 (27.2)	2,104 (19.3)		1,498 (18.1)	549 (26.1)	57 (10.9)	
75+ y	23,779 (23.8)	1,487 (13.6)		919 (11.1)	542 (25.7)	26 (5.0)	
Sex			0.004				0.2
Male	51,180 (51.2)	5,678 (52.1)		4,286 (51.8)	1,114 (52.9)	278 (53.4)	
Female	46,573 (46.6)	4,935 (45.3)		3,751 (45.4)	951 (45.2)	233 (44.7)	

Demographic	Vulnerable status		Type of vulnerable hospital			p Value
	Nonvulnerable (n = 99,963)	Vulnerable hospitals (n = 10,894)	Safety net hospitals (n = 8,267)	High Medicaid hospitals (n = 2,106)	High Medicaid and safety net hospitals (n = 521)	
Charlson Index						<0.001
0	58,404 (58.4)	6,867 (63.0)	5,435 (65.7)	1,118 (53.1)	314 (60.3)	
1	26,466 (26.5)	2,704 (24.8)	1,949 (23.6)	630 (29.9)	125 (24.0)	
2+	15,093 (15.1)	1,323 (12.1)	883 (10.7)	358 (17.0)	82 (15.7)	
Race						<0.001
NH white	67,012 (67.0)	5,148 (47.3)	4,307 (52.1)	568 (27.0)	273 (52.4)	
NH black	5,634 (5.6)	904 (8.3)	578 (7.0)	273 (13.0)	53 (10.2)	
Hispanic	13,720 (13.7)	2,964 (27.2)	1,973 (23.9)	860 (40.8)	131 (25.1)	
Asian/Pacific Islanders	10,201 (10.2)	1,291 (11.9)	953 (11.5)	300 (14.2)	38 (7.3)	
Other	3,396 (3.4)	587 (5.4)	456 (5.5)	105 (5.0)	26 (5.0)	
Median ZIP-level income						<0.001
1st Quartile	16,545 (16.6)	3,028 (27.8)	1,916 (23.2)	918 (43.6)	194 (37.2)	
2nd Quartile	19,752 (19.8)	2,362 (21.7)	1,805 (21.8)	456 (21.7)	101 (19.4)	
3rd Quartile	23,700 (23.7)	2,138 (19.6)	1,777 (21.5)	252 (12.0)	109 (20.9)	
4th Quartile	25,411 (25.4)	1,843 (16.9)	1,617 (19.6)	188 (8.9)	38 (7.3)	
Primary payer						<0.001
Private	41,757 (41.8)	2,509 (23.0)	2,020 (24.4)	444 (21.1)	45 (8.6)	
Medicare	49,726 (49.7)	3,957 (36.3)	2,827 (34.2)	1,039 (49.3)	91 (17.5)	
Medicaid	5,002 (5.0)	2,928 (26.9)	2,222 (26.9)	494 (23.5)	212 (40.7)	

Demographic	Vulnerable status		Type of vulnerable hospital				p Value
	Nonvulnerable (n = 99,963)	Vulnerable hospitals (n = 10,894)	Safety net hospitals (n = 8,267)	High Medicaid hospitals (n = 2,106)	High Medicaid and safety net hospitals (n = 521)		
Other	3,478 (3.5)	1,500 (13.8)	1,198 (14.5)	129 (6.1)	173 (33.2)	<0.001	
Route of admission						<0.001	
Routine	91,516 (91.5)	9,301 (85.4)	7,371 (89.2)	1,553 (73.7)	377 (72.4)		
Emergency	8,447 (8.5)	1,593 (14.6)	896 (10.8)	553 (26.3)	144 (27.6)		
No. of beds						<0.001	
1 to 99	3,863 (3.9)	106 (1.0)	0 (0.0)	106 (5.0)	0 (0.0)		
100 to 399	62,570 (62.6)	4,890 (44.9)	3,047 (36.9)	1,322 (62.8)	521 (100)		
400+	31,108 (31.1)	5,890 (54.1)	5,220 (63.1)	670 (31.8)	0 (0.0)		
Hospital ownership						<0.001	
Public	9,630 (9.6)	8,868 (81.4)	8,267 (100)	80 (3.8)	521 (100)		
Private, not for profit	81,409 (81.4)	1,355 (12.4)	0 (0.0)	1,355 (64.3)	0 (0.0)		
Private, for profit	6,502 (6.5)	663 (6.1)	0 (0.0)	663 (31.5)	0 (0.0)		
Teaching						<0.001	
Yes	44,224 (44.2)	9,608 (88.2)	8,095 (97.9)	992 (47.1)	521 (100)		
No	53,317 (53.3)	1,278 (11.7)	172 (2.1)	1,106 (52.5)	0 (0.0)		
Cancer program						<0.001	
Yes	56,726 (56.7)	8,367 (76.8)	7,061 (85.4)	994 (47.2)	312 (59.9)		
No	40,815 (40.8)	2,519 (23.1)	1,206 (14.6)	1,104 (52.4)	209 (40.1)		
Procedure volume						<0.001	

Demographic	Vulnerable status		Type of vulnerable hospital			p Value
	Nonvulnerable (n = 99,963)	Vulnerable hospitals (n = 10,894)	Safety net hospitals (n = 8,267)	High Medicaid hospitals (n = 2,106)	High Medicaid and safety net hospitals (n = 521)	
Low	32,335 (32.3)	4,219 (38.7)	2,022 (24.5)	1,690 (80.2)	507 (97.3)	
Medium	33,227 (33.2)	3,222 (29.6)	2,898 (35.1)	310 (14.7)	14 (2.7)	
High	34,401 (34.4)	3,453 (31.7)	3,347 (40.5)	106 (5.0)	0 (0.0)	

Data are presented as n (%).

NH, non-Hispanic.

Table 2

Distribution of Structural Characteristics among Hospitals that Performed Major Cancer Surgery in California, State Inpatient Database of California, 2004 to 2011 (n = 355)

Characteristic	Vulnerable status		Type of vulnerable hospital		
	Nonvulnerable hospitals* (n = 306)	Vulnerable hospitals* (n = 49)	Safety net hospitals (n = 13)	High Medicaid hospitals* (n = 31)	High Medicaid and safety net hospitals (n = 5)
No. of beds					
1 to 99	67 (21.9)	2 (4.1)	0 (0.0)	2 (6.5)	0 (0.0)
100 to 399	192 (62.8)	35 (71.4)	7 (53.9)	23 (74.2)	5 (100.0)
400+	24 (7.8)	9 (18.4)	6 (46.2)	3 (9.7)	0 (0.0)
Hospital ownership					
Public	40 (13.1)	20 (40.8)	13 (100)	2 (6.5)	5 (100.0)
Private, not for profit	190 (62.1)	11 (22.5)	0 (0.0)	11 (35.5)	0 (0.0)
Private, for profit	53 (17.3)	15 (30.6)	0 (0.0)	15 (48.4)	0 (0.0)
Teaching [‡]					
Yes	49 (16.0)	22 (44.9)	11 (84.6)	6 (19.4)	5 (100.0)
No	234 (76.5)	24 (49)	2 (15.4)	22 (71.0)	0 (0.0)
Cancer program [‡]					
Yes	96 (31.4)	14 (28.6)	7 (53.9)	5 (16.1)	2 (40.0)
No	187 (61.1)	32 (65.3)	6 (46.2)	23 (74.2)	3 (60.0)

Data are presented as n (%).

* Column numbers do not add up to the total number and column percentages do not sum to 100% due to missing information on hospital characteristics in the American Hospital Association survey database.

Author Manuscript

[†] Approved by ACGME.

[‡] Approved by the American College of Surgeons.

Author Manuscript

Author Manuscript

Author Manuscript

Odds Ratios of Readmissions among Major Cancer Surgery Patients Treated at Vulnerable Hospitals vs Nonvulnerable Hospitals, State Inpatient Database of California, 2004 to 2011 (N = 110,857)

Table 3

Hospital	Model 1: unadjusted	Model 2: HRRP* covariates	Model 3: HRRP + other patient covariates [†]		Model 4: HRRP + hospital covariates [‡]		Model 5: HRRP + patient + hospital covariates
	OR (95% CI)	OR (95% CI)	OR (95% CI)	% Change in OR [§]	OR (95% CI)	% Change in OR [§]	OR (95% CI)
Safety net hospitals							
30-Day	1.26 (1.07–1.48) ^{//}	1.32 (1.18–1.47) ^{//}	1.24 (1.09–1.41) ^{//}	24	1.13 (0.98–1.30)	60	1.07 (0.93–1.25)
90-Day	1.18 (1.03–1.35) [#]	1.28 (1.18–1.38) ^{//}	1.17 (1.04–1.30) ^{//}	39	1.09 (0.96–1.25)	66	1.02 (0.89–1.16)
Repeated	1.33 (1.12–1.58) ^{//}	1.33 (1.18–1.49) ^{//}	1.20 (1.01–1.42) [#]	39	1.02 (0.87–1.20)	93	0.95 (0.79–1.13)
High Medicaid hospitals							
30-Day	1.18 (1.05–1.32) ^{//}	1.10 (0.97–1.25)	0.98 (0.86–1.13)	115	1.09 (0.96–1.23)	15	0.99 (0.87–1.13)
90-Day	1.38 (1.25–1.53) ^{//}	1.28 (1.16–1.42) ^{//}	1.11 (1.00–1.24) [#]	60	1.26 (1.13–1.39) ^{//}	10	1.11 (1.01–1.23) [#]
Repeated	1.36 (1.07–1.72) [#]	1.24 (1.01–1.54) [#]	1.04 (0.85–1.29)	82	1.22 (0.97–1.55)	9	1.06 (0.85–1.31)
High Medicaid safety net hospitals							
30-Day	1.29 (1.03–1.62) [#]	1.28 (1.05–1.56) [#]	1.13 (0.98–1.31)	52	1.09 (0.87–1.36)	69	0.99 (0.83–1.18)
90-Day	1.25 (0.96–1.64)	1.28 (0.99–1.65)	1.08 (0.90–1.30)	71	1.06 (0.81–1.41)	77	0.93 (0.75–1.16)
Repeated	1.71 (1.17–2.50) ^{//}	1.54 (1.10–2.17) [#]	1.24 (0.89–1.73)	55	1.20 (0.85–1.69)	63	1.01 (0.72–1.43)

Numbers in the table have been rounded.

* The HRRP covariates include patient's age, sex, Charlson Index, type and year of procedure.

[†] Other patient covariates include patient's race, primary insurance, quartile of ZIP-area median income in California, and route of admission for index surgery.

[‡] Hospital covariates include number of beds, ownership, teaching status, and Commission on Cancer-approved cancer program.

§ Calculated as $(\text{OR}_{\text{Model 2}} - \text{OR}_{\text{Model 3 or 4}}) / (\text{OR}_{\text{Model 2}} - 1) \times 100\%$. For example, for estimated OR of 30-day readmission for safety net vs nonvulnerable hospitals in model 3, the change in OR was $(1.3177 - 1.2409) / (1.3177 - 1) \times 100\% = 24.2\%$.

¶ $p < 0.01$.

¶ $p < 0.001$.

$p < 0.05$.

HRRP, Hospital Readmission Readmission Program; OR, odds ratio.

Table 4

Adjusted Odds Ratios of Readmissions Associated with Patient and Hospital Characteristics among Patients of Major Cancer Surgery, State Inpatient Database of California, 2004 to 2011 (N = 110,857)

Characteristic	30-Day readmission	90-Day readmission	Repeated readmission
Type of hospital (ref = nonvulnerable)			
Safety net	1.07 (0.93–1.25)	1.02 (0.89–1.16)	0.95 (0.79–1.13)
High Medicaid	0.99 (0.87–1.13)	1.11 (1.01–1.23) *	1.06 (0.85–1.31)
High Medicaid safety net	0.99 (0.83–1.18)	0.93 (0.75–1.16)	1.01 (0.72–1.43)
Procedure type (ref = rectal)			
Esophageal	1.29 (1.10–1.51) †	1.46 (1.28–1.67) †	1.73 (1.38–2.15) †
Gastric	1.18 (1.07–1.30) †	1.36 (1.27–1.46) †	1.31 (1.12–1.53) †
Liver	1.14 (0.97–1.35)	1.09 (0.91–1.30)	1.37 (1.02–1.84) *
Pancreatic	1.60 (1.45–1.76) †	1.59 (1.47–1.72) †	1.77 (1.50–2.10) †
Lung	0.70 (0.64–0.76) †	0.79 (0.74–0.84) †	0.71 (0.61–0.82) †
Kidney	0.55 (0.50–0.60) †	0.57 (0.52–0.61) †	0.63 (0.56–0.72) †
Age (ref = 18 to 49 y)			
50 to 64 y	0.91 (0.85–0.97) †	0.97 (0.92–1.03)	0.85 (0.77–0.94) †
65 to 74 y	0.84 (0.77–0.93) †	0.88 (0.81–0.96) †	0.60 (0.52–0.70) †
75+ y	0.93 (0.83–1.04)	1.02 (0.93–1.12)	0.64 (0.53–0.77) †
Sex (ref = female)			
Male	1.10 (1.05–1.15) †	1.10 (1.06–1.14) †	1.02 (0.94–1.10)
Charlson Index (ref = 0)			
1	1.23 (1.17–1.29) †	1.22 (1.17–1.27) †	1.44 (1.32–1.56) †
2+	1.87 (1.75–2.00) †	1.96 (1.87–2.06) †	2.32 (2.12–2.54) †
Year of admission	1.00 (0.99–1.01)	0.99 (0.98–0.99) †	0.99 (0.97–1.01)
Race (ref = non-Hispanic white)			
Non-Hispanic black	1.06 (1.00–1.12) *	1.06 (1.01–1.12) *	0.96 (0.87–1.06)
Hispanic	1.11 (1.02–1.20) *	1.10 (1.03–1.18) †	1.10 (0.96–1.26)
Asian/Pacific Islander	0.91 (0.85–0.98) *	0.92 (0.87–0.97) †	0.87 (0.77–1.00) *
Other	0.84 (0.74–0.96) *	0.86 (0.77–0.95) †	0.69 (0.56–0.87) †
ZIP-level income median (ref = 4 th quartile)			
1 st Quartile	0.98 (0.92–1.05)	1.04 (0.99–1.10)	1.06 (0.94–1.19)
2 nd Quartile	1.02 (0.96–1.08)	1.04 (0.99–1.10)	1.10 (0.99–1.23)
3 rd Quartile	1.01 (0.95–1.06)	1.02 (0.97–1.07)	1.01 (0.92–1.12)
Primary payer (ref = private)			
Medicare	1.30 (1.20–1.41) †	1.36 (1.26–1.46) †	1.60 (1.39–1.84) †

Characteristic	30-Day readmission	90-Day readmission	Repeated readmission
Medicaid	1.33 (1.20–1.47) [‡]	1.47 (1.36–1.59) [‡]	1.63 (1.43–1.85) [‡]
Other	0.89 (0.78–1.02)	0.89 (0.78–1.03)	0.88 (0.70–1.10)
Route of admission (ref = routine)			
Emergency	1.51 (1.41–1.63) [‡]	1.51 (1.41–1.62) [‡]	1.79 (1.59–2.02) [‡]
No. of beds (ref = 400+)			
1 to 99	0.96 (0.82–1.12)	1.02 (0.85–1.22)	1.17 (0.89–1.54)
100 to 399	1.03 (0.95–1.11)	1.06 (0.98–1.14)	1.10 (0.98–1.23)
Hospital ownership (ref = non-federal government)			
Private, not-for-profit	0.92 (0.84–1.01)	0.92 (0.84–1.01)	0.84 (0.75–0.94) [‡]
Private, for profit	0.97 (0.84–1.13)	0.98 (0.87–1.10)	1.04 (0.86–1.25)
Teaching (ref = no)			
Yes	1.15 (1.07–1.24) [‡]	1.14 (1.06–1.22) [‡]	1.23 (1.11–1.38) [‡]
Cancer program (ref = no)			
Yes	1.03 (0.96–1.10)	1.07 (1.00–1.15) [*]	1.03 (0.94–1.13)
Procedure volume (ref = high)			
Low	0.96 (0.89–1.03)	0.97 (0.91–1.04)	0.85 (0.75–0.95) [‡]
Medium	1.00 (0.94–1.07)	0.99 (0.94–1.04)	0.94 (0.85–1.04)

Data are presented as odds ratio (95% CI).

^{*} p < 0.05.

[‡] p < 0.01.

[‡] p < 0.001.